E-learning

'The Cerebro Placental Ratio Doppler Ultrasound'

This e-learning 'CPR Doppler Ultrasound' is based on the ISUOG Practice Guidelines: 'use of Doppler ultrasonography in obstetrics'.[1] It is meant for all sonographers, clinicians and midwifes who perform the CPR measurement for the DRIGITAT and CEPRA study purpose.

SUMMARY

The Cerebro Placental Ratio (CPR) is calculated by dividing the Doppler pulsatility index of the middle cerebral artery (MCA) by the umbilical artery (UA) pulsatility index.

For both umbilical artery and middle cerebral artery

- Preferably measure in the absence of fetal movements.
- Look for insonation angle as small as possible but at least less than 60 degrees. Preferably adjust angle, although this is less relevant for pulsatility index (PI).
- Use high-definition zoom to limit view (and the machine's processor capacity) to focus as much as possible on the sampling site.
- Adjust filter, power and pulse repetition frequency so that the amplitude of the flow velocities is approximately two thirds of the y-axis.
- Use a series of 4-6 complete waveforms to measure the PI, check that the software adequately tracks the waveform.
- Repeat 2-3 times and choose the best recording, which is usually the lowest PI (or the highest in case of reversed end-diastolic flow).

For umbilical artery

- Record in free-floating loop, preferably not too close to abdominal wall or placenta.

For middle cerebral artery

- Identify in 2D setting the transversal plane of BPD/HC, move probe more caudally until you identify the X-like bony structures of the skull base / sphenoid; then add colour to identify the circle of Willis.
- Record flow velocity in waveform just past the level of the bifurcation of the internal carotid artery (Circle of Willis) into the anterior and middle cerebral artery, rough guideline 1/3 to 1/4 distance between Circle and temporal bone.
- Angle correction advisable, but not strictly necessary for PI.

For those who wish an **extended description** please find below the more specified texts.

UMBILICAL ARTERY

What is the appropriate technique for obtaining umbilical artery Doppler waveforms?

There is a significant difference in Doppler indices measured at the fetal end, the free loop and the placental end of the umbilical cord[2]. The impedance is highest at the fetal end, and absent/reversed end-diastolic flow is likely to be seen first at this site. Reference ranges for umbilical artery Doppler indices at these sites have been published[3, 4]. For the sake of simplicity and consistency, measurements should be made in a free cord loop.

Figure 1 shows acceptable and unacceptable velocity waveform recordings. Figure 2 shows the influence of vessel wall filter.

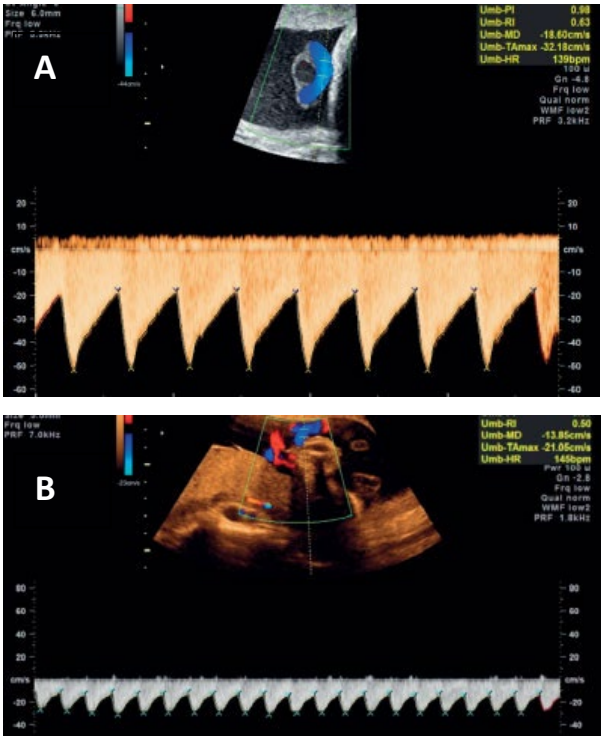

Figure 1 Acceptable (a) and unacceptable (b) umbilical artery waveforms. In (b), waveforms are too small and sweep speed too slow.

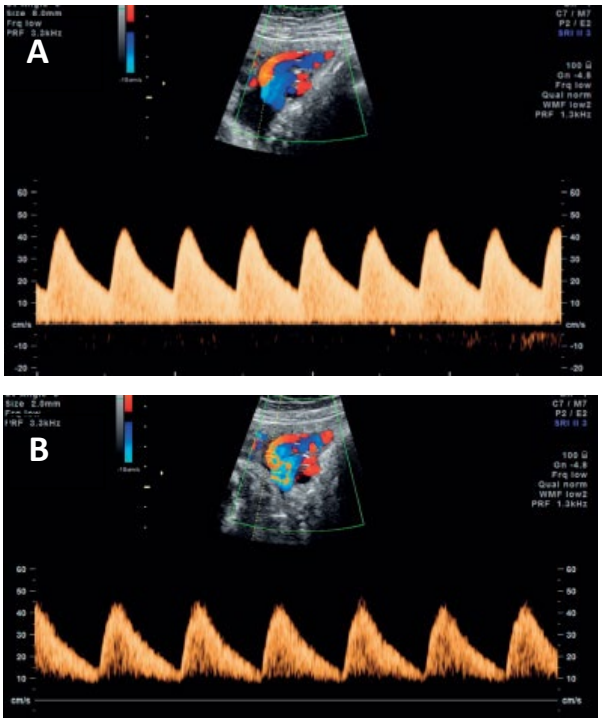

Figure 2 Umbilical artery waveforms obtained from same fetus, within 4 min of each other, showing: (a) normal flow and (b) apparently very low diastolic flow and absent flow signals at baseline, due to use of incorrect vessel wall filter (velocity reject is set too high).

Note: In a two-vessel cord, at any gestational age, the diameter of the single umbilical artery is larger than when there are two arteries and the impedance is thus lower[5].

MIDDLE CEREBRAL ARTERY

What is the appropriate technique for obtaining fetal middle cerebral artery Doppler waveforms?

- An axial section of the brain, including the thalami and the sphenoid bone wings, should be obtained and magnified.
- Colour flow mapping should be used to identify the circle of Willis and the proximal MCA (Figure 3).
- The pulsed-wave Doppler gate should then be placed at the proximal third of the MCA, close to its origin in the internal carotid artery[5] (the systolic velocity decreases with distance from the point of origin of this vessel).
- The angle between the ultrasound beam and the direction of blood flow should be kept as close as possible to 0◦ (Figure 4).
- Care should be taken to avoid any unnecessary pressure on the fetal head.
- At least three and fewer than 10 consecutive waveforms should be recorded. The highest point of the waveform is considered as the peak systolic velocity (PSV (cm/s)).

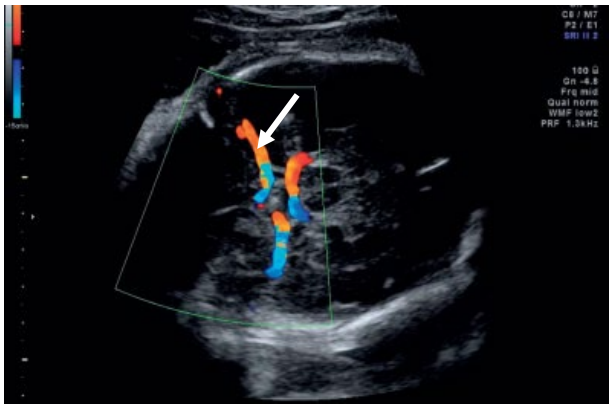

Figure 3 Colour flow mapping of circle of Willis. The arrow illustrates the proximal third MCA.

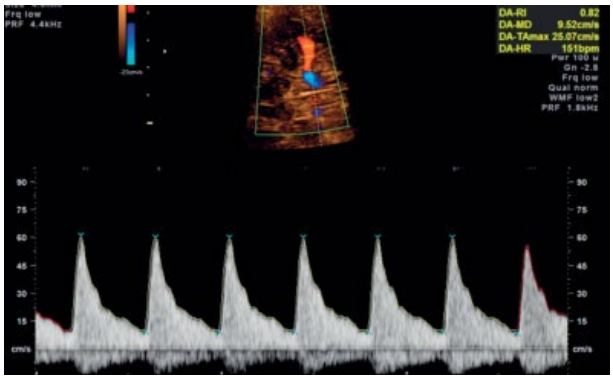

Figure 4 Acceptable middle cerebral artery Doppler shift waveform. Note insonation angle near 0◦.

PRINCIPLES OF DOPPLER ULTRASOUND

Pulsed wave Doppler ultrasonography

- Recordings should be obtained during absence of fetal breathing and body movements, and if necessary during temporary maternal breath hold.
- Colour flow mapping is not mandatory, although it is very helpful in the identification of the vessel of interest and in defining the direction of blood flow.
- The optimal insonation is complete alignment with the blood flow. This ensures the best conditions for assessing absolute velocities and waveforms. Small deviations in angle may occur. An insonation angle of 10◦ corresponds to a 2% velocity error whilst a 20◦ angle corresponds to 6% error. When absolute velocity is the clinically important parameter (e.g. middle cerebral artery (MCA)) and an angle of > 20◦ is obtained, angle correction may be used, but this in itself may lead to error. In this case, if the recording is not improved by repeated insonations, a statement should be added to any report stating the angle of insonation and whether angle correction was carried out or that the uncorrected velocity is recorded.
- It is advisable to start with a relatively wide Doppler gate (sample volume) to ensure the recording of maximum velocities during the entire pulse. If interference from other vessels causes problems the gate can be reduced to refine the recording. Keep in mind that the sample volume can be reduced only in height, not in width.
- Similar to grey-scale imaging, the penetration and resolution of the Doppler beam can be optimized by adjusting the frequency (MHz) of the Doppler probe.
- The vessel wall filter, alternatively called 'low velocity reject', 'wall motion filter' or 'high pass filter', is used to eliminate noise from the movement of the vessel walls. By convention, it should be set as low as possible (≤ 50–60 Hz) in order to eliminate the low frequency noise from peripheral blood vessels. When using a higher filter, a spurious effect of absent end-diastolic velocity (EDV) can be created (see Figure 2b).
- Doppler horizontal sweep speed should be fast enough to separate successive waveforms. Ideal is a display of four to six (but no more than eight to 10) complete cardiac cycles. For fetal heart rates of 110–150 bpm, a sweep speed of 50–100 mm/s is adequate.
- Pulse repetition frequency (PRF) should be adjusted according to the vessel studied: low PRF will enable visualization and accurate measurement of low velocity flow; however, it will produce aliasing when high velocities are encountered. The waveform should fit at least 75% of the Doppler screen (see Figure 1).
- Doppler measurements should be reproducible. If there is obvious discrepancy between measurements, a repeat recording is recommended. Conventionally, the measurement closest to the expected is chosen for the report unless it is technically inferior.
- In order to increase the quality of Doppler recordings, a frequent update of the real-time grey-scale or colour Doppler image should be performed (i.e. after confirming in the real-time image that the Doppler gate is positioned correctly, the two-dimensional (2D) and/or colour Doppler image should be frozen when the Doppler waveforms are being recorded).
- Ensure a correct position and optimize the Doppler recording of the frozen 2D image by listening to the audible representation of the Doppler shift over the loudspeaker.
- Gain should be adjusted in order to see clearly the Doppler velocity waveform, without the presence of artefacts in the background of the display.

REFERENCES

1. Bhide A, Acharya G, Bilardo C, et al. ISUOG practice guidelines: use of Doppler ultrasonography in obstetrics. Ultrasound in obstetrics & gynecology: the official journal of the International Society of Ultrasound in Obstetrics and Gynecology. 2013;41(2):233.
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6. Mari G, Deter RL, Carpenter RL, et al. Noninvasive diagnosis by Doppler ultrasonography of fetal anemia due to maternal red-cell alloimmunization. New England Journal of Medicine. 2000;342(1):9-14.